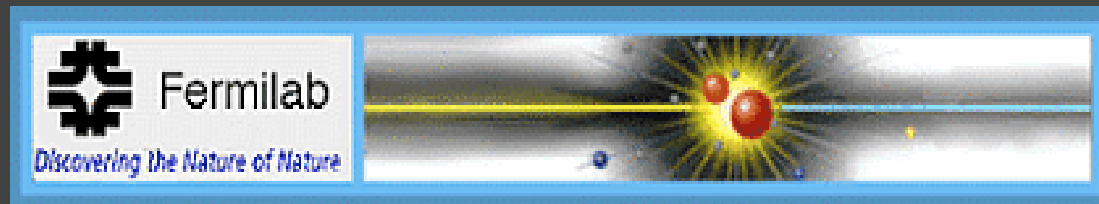
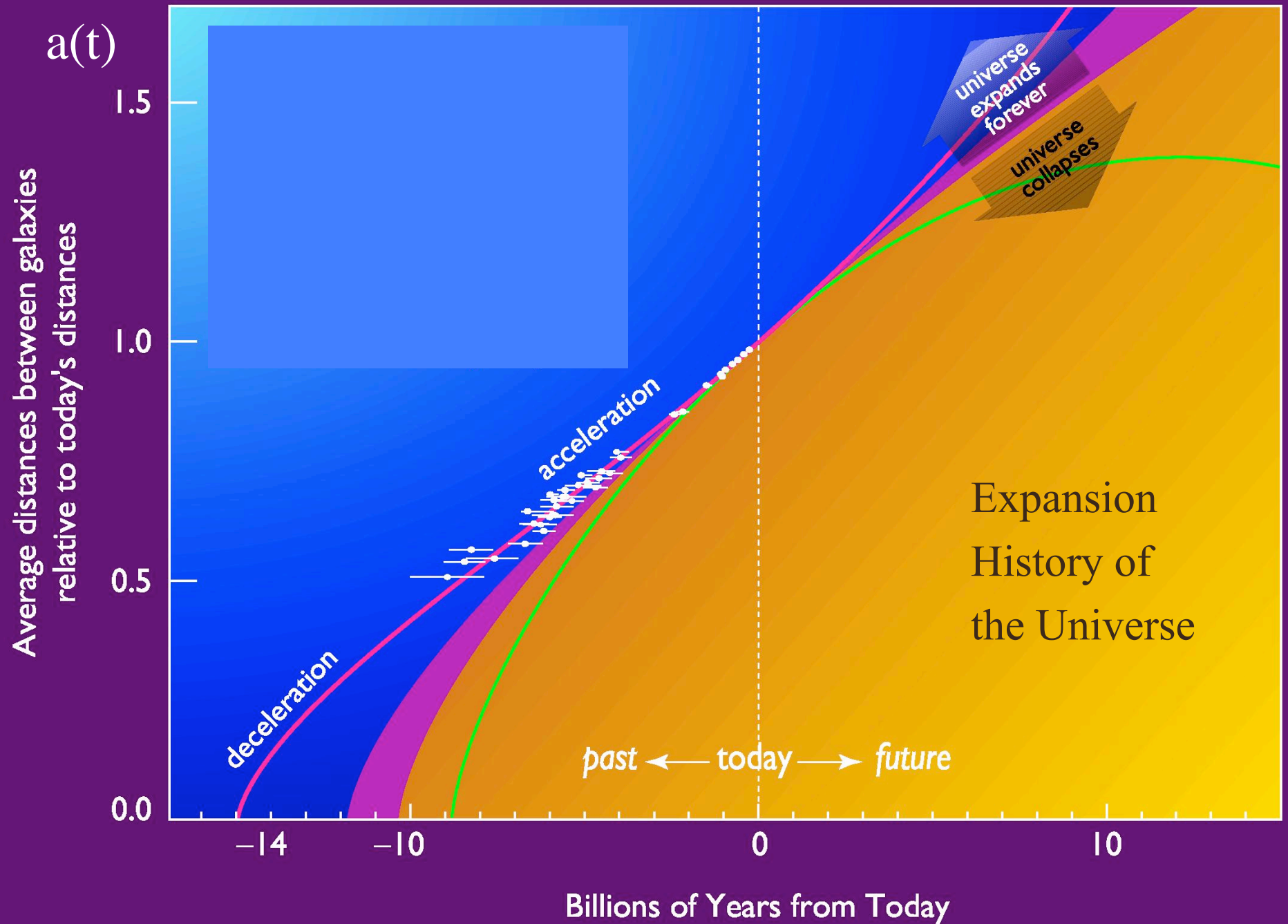


Probing Dark Energy with SDSS Supernovae

Josh Frieman





Dark Energy and the Accelerating Universe

Brightness of distant Type Ia supernovae, along with CMB and galaxy clustering data, indicates the expansion of the Universe is accelerating, not decelerating.

This requires *either* a new form of stress-energy with negative effective pressure *or* a breakdown of General Relativity at large distances:

DARK ENERGY

Characterize by its effective equation of state:
and its relative contribution to the present
density of the Universe:

Special case: cosmological constant: $w = -1$

$$w(z) = p/\rho$$

$$\Omega_{\text{DE}}$$

Type Ia SN Peak Brightness as a calibrated 'Standard' Candle

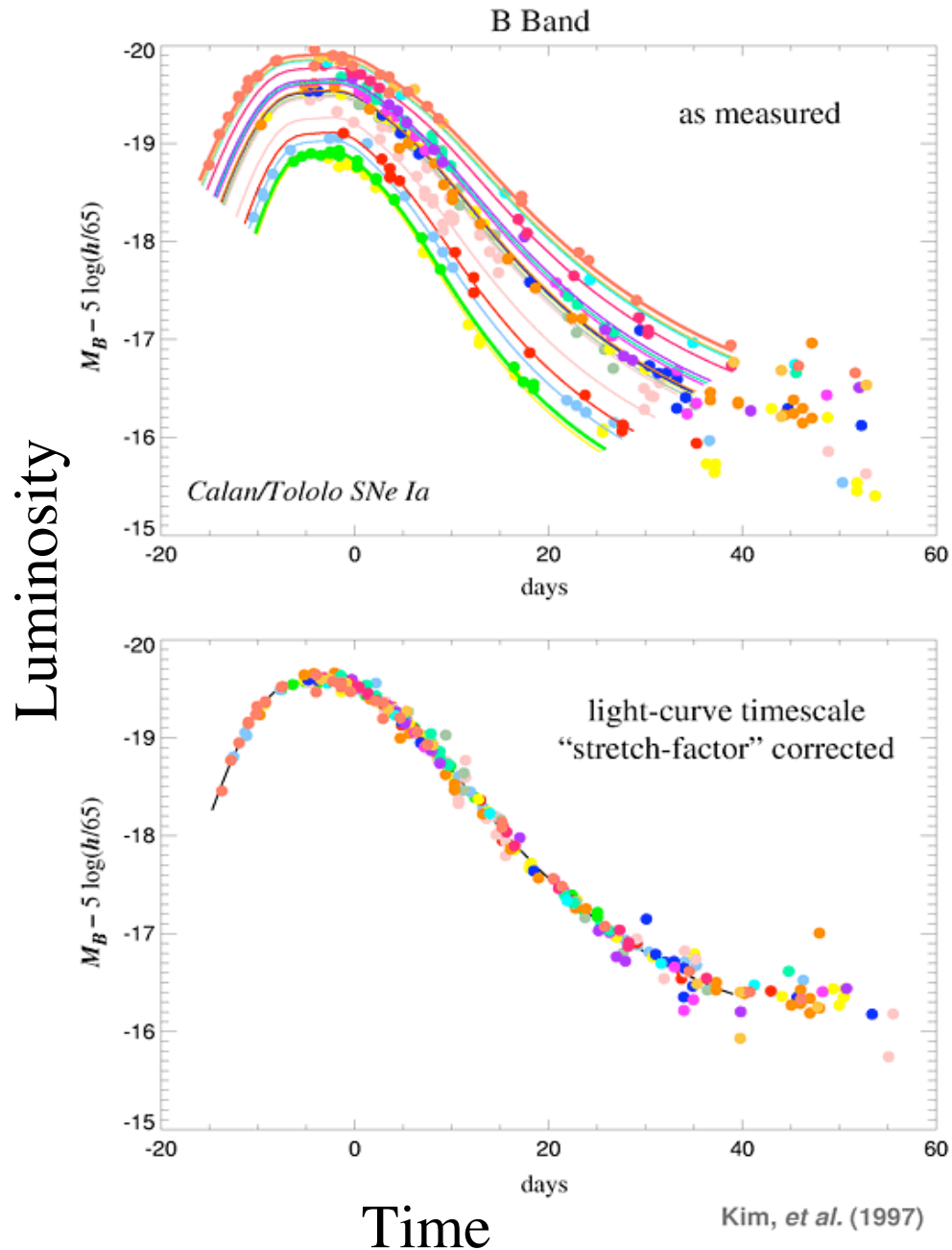
Peak brightness
correlates with
decline rate

Phillips

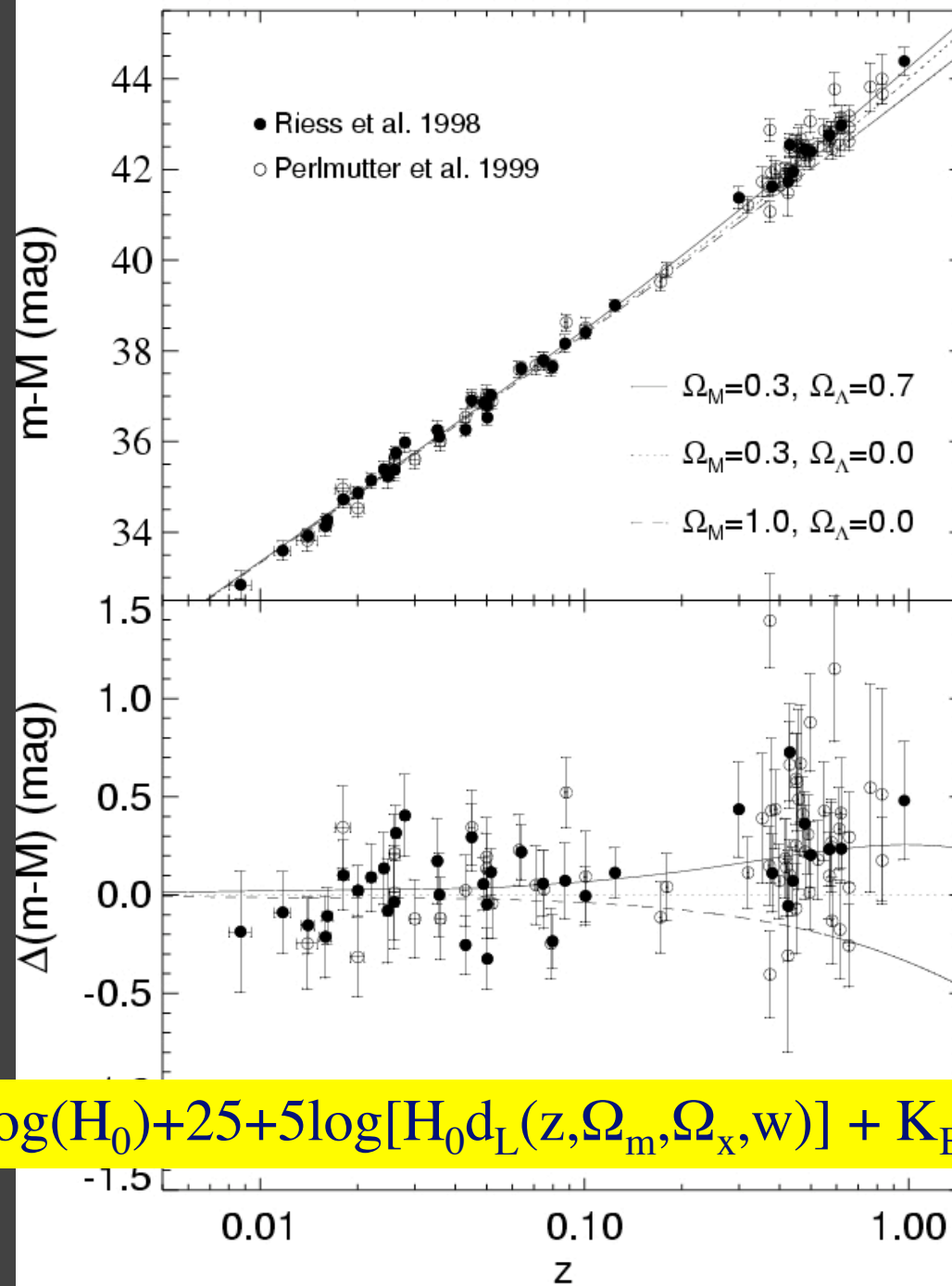
After correction,
 $\sigma \sim 0.12$ mag

(~6% distance error)

Feb. 24, 2005



Cosmology from High-z SN Samples



$$\begin{aligned}\Omega_\Lambda &= 0.7 \\ \Omega_\Lambda &= 0. \\ \Omega_m &= 1.\end{aligned}$$

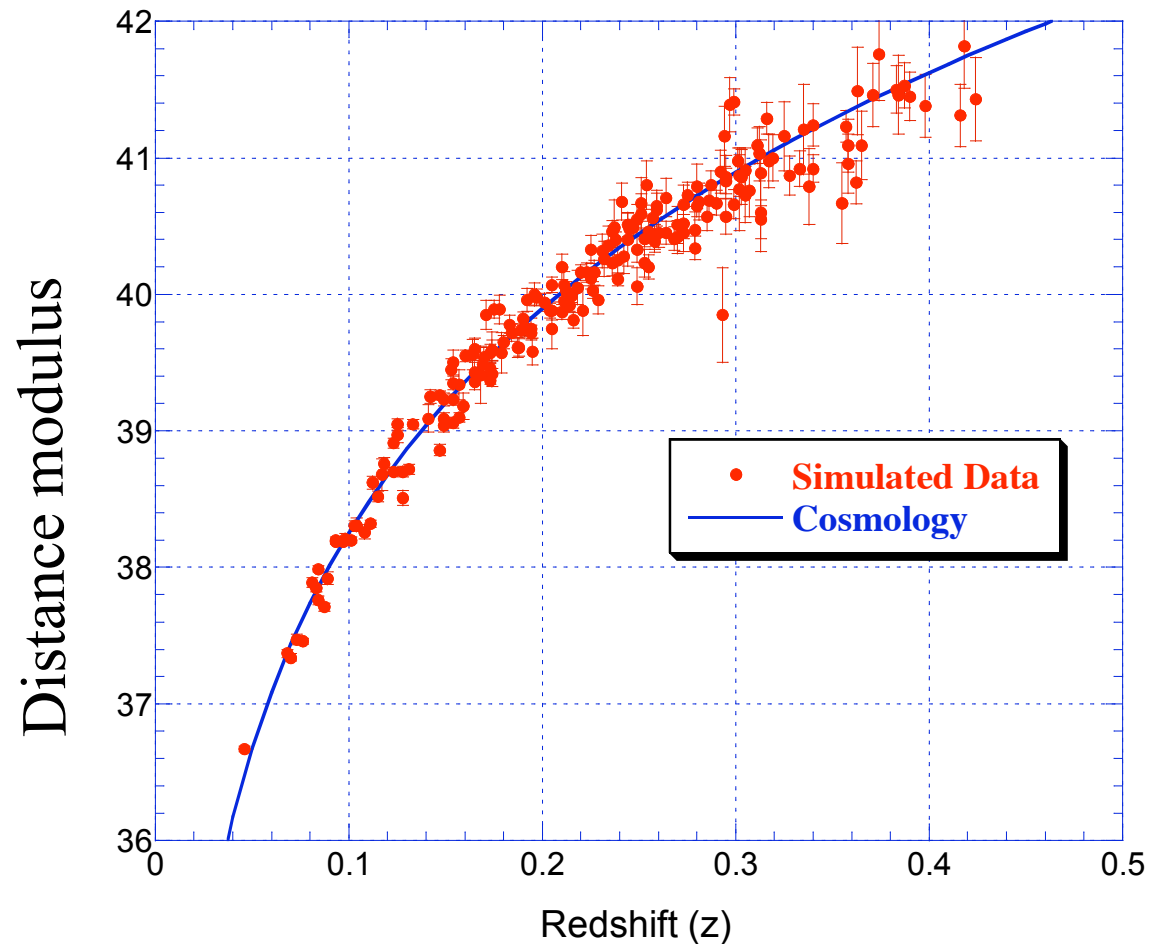
$$m(z) = M_B - 5\log(H_0) + 25 + 5\log[H_0 d_L(z, \Omega_m, \Omega_x, w)] + K_{Bx} + A$$

SDSS SN Science Goals

- Obtain ~ 200 *high-quality* SNe in the redshift desert:
repeat multi-band data over ~ 250 square degrees
- Probe Dark Energy in z regime less sensitive to evolution than deeper surveys
- Study SN Ia systematics (critical for SN cosmology) with high photometric accuracy
- Search for additional parameters to reduce Ia dispersion
- Determine SN/SF rates/properties vs. z , environment
- Rest-frame u -band templates for $z > 1$ surveys
- Study feasibility of cosmology with SN colors
- Database of Type II and rare SN light-curves

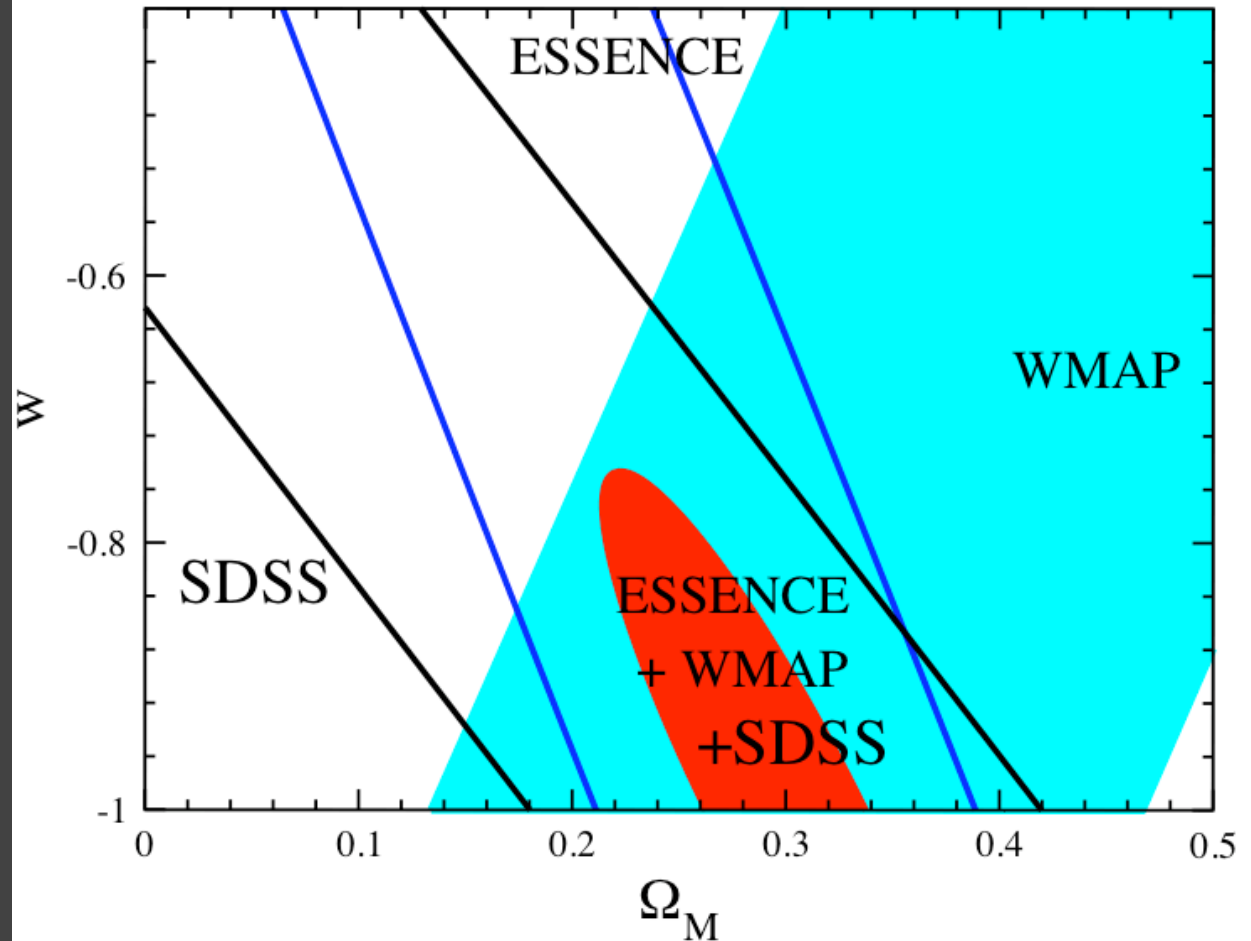
Monte Carlo Data

Simulated
redshift
distribution
and photometric
errors for
completed
SDSS SN sample
(here assumed
 $\Omega_{\Lambda}=0.7=1-\Omega_m$
 $H_0=72$)



Forecast Cosmological Constraints

Combining SDSS with deeper survey leads to improved constraints, due to broader redshift leverage.

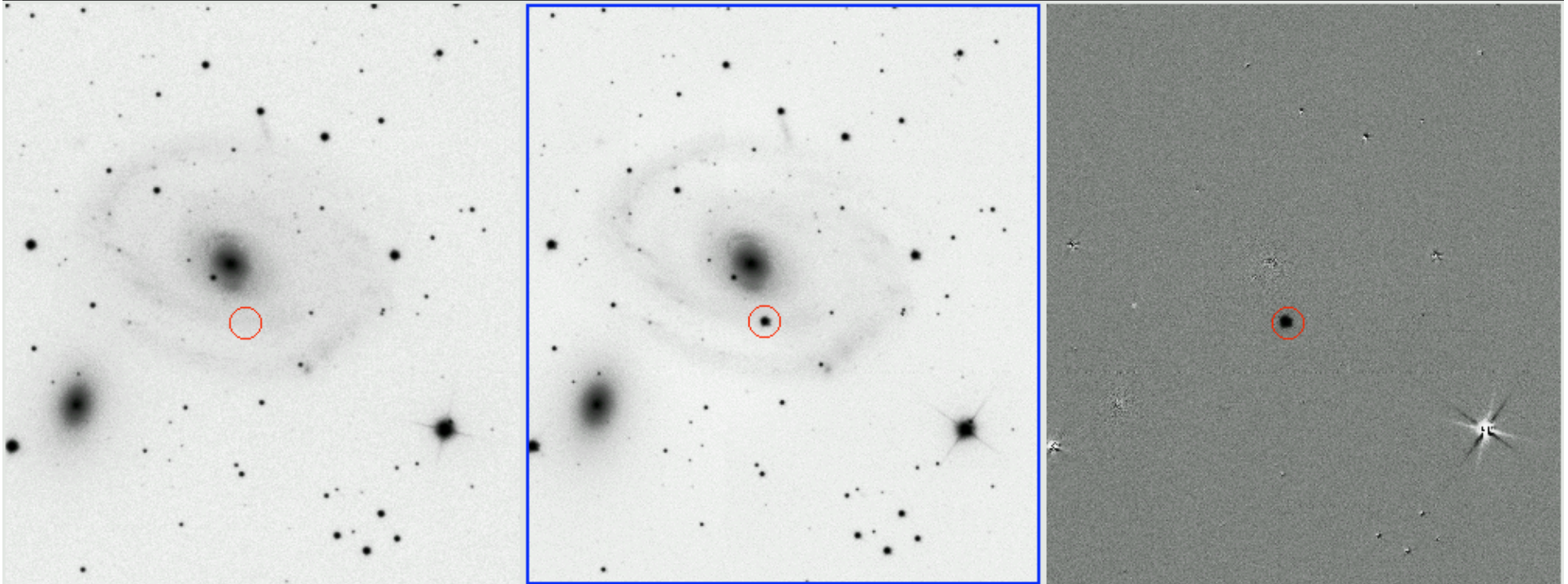


$\sigma(w) = 0.10$ from SDSS+ESSENCE+WMAP+LSS
(statistical errors only, constant w , flat Universe)

Fall 2004: Early Science & Test Run

- **Imaging:** 20 nights of SDSS 2.5m scheduled every other night late Sept.-mid Nov., covered half the survey area: $\sim 1/2$ the nights were useable.
- **Follow-up spectroscopy:** ARC 3.5m, HET 9.2m
- **Science Goal:** ~ 10 well-measured SN Ia light-curves with confirmed spectroscopic types and redshifts.
- **Yield:** 16 confirmed Ia's: $0.05 < z < 0.32$ with $\langle z \rangle = 0.15$,
5 Type II, 1 luminous Type Ic
- **Engineering goals met:**
 - Rapid processing and selection of candidates in g,r (~ 48 hours)
 - Coordinated follow-up observations
 - Study detection efficiency and photometric accuracy under varying conditions

Finding SNe: Frame Subtraction



Before

After

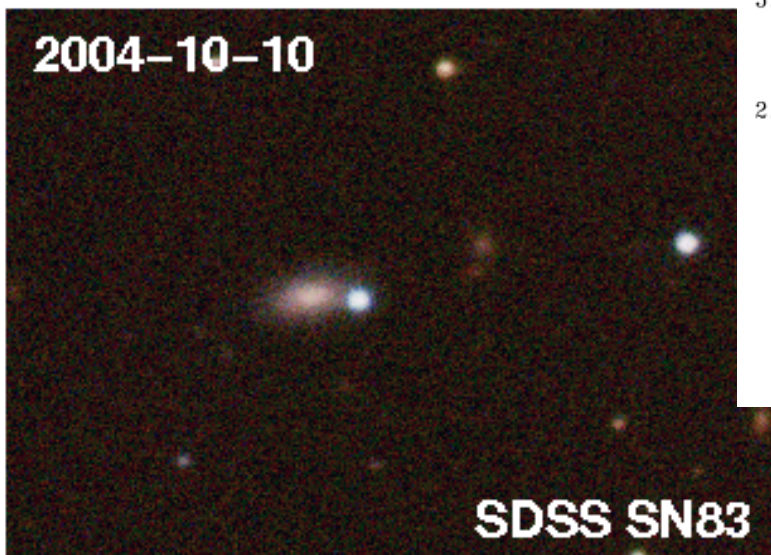
Difference

sn2002ha (Ia) $z = 0.014$ from LOTOSS seen in SDSS data (g band)

2004-09-24

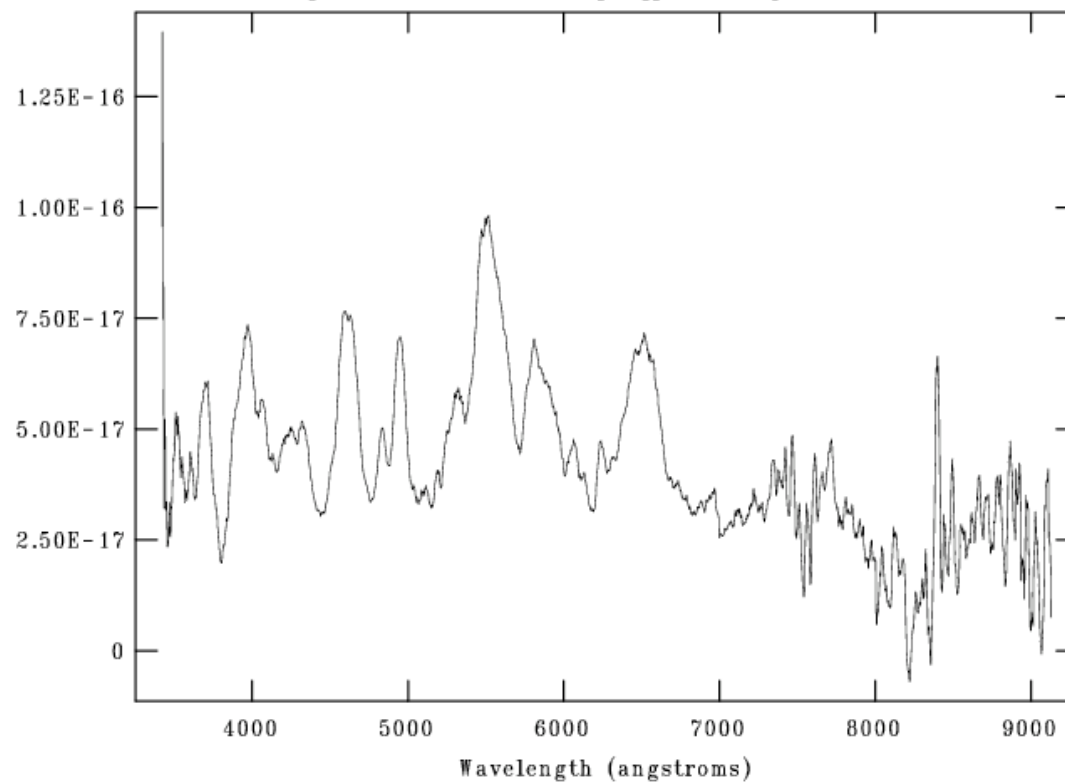


2004-10-10



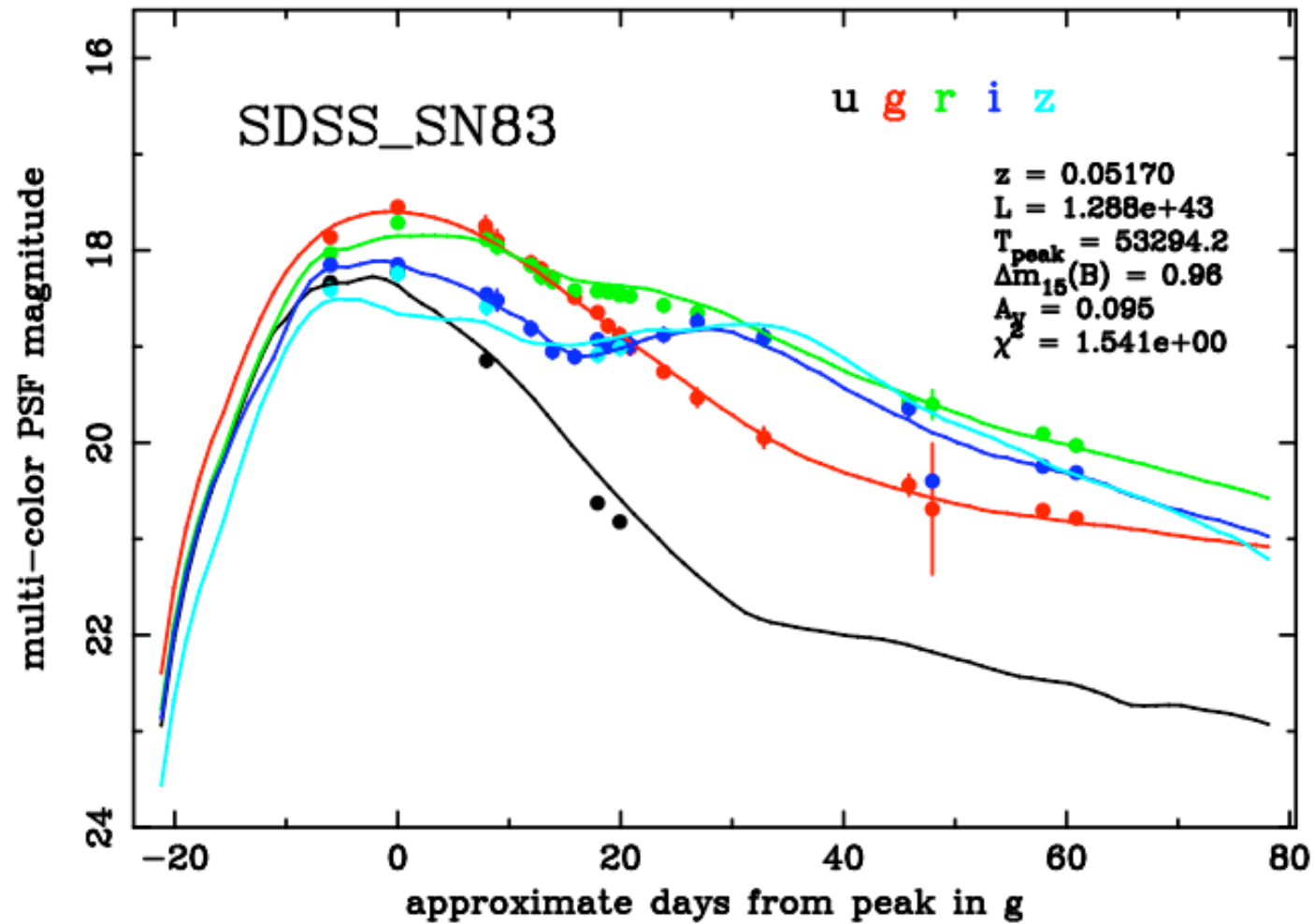
SDSS SN83

NOAO/IRAF V2.12.2-EXPORT marriner@marriner Mon 10:50:33 22-Nov-2004
[sn83_comb_z.ms.fc.fits[*],1]: 900. ap:1 beam:1

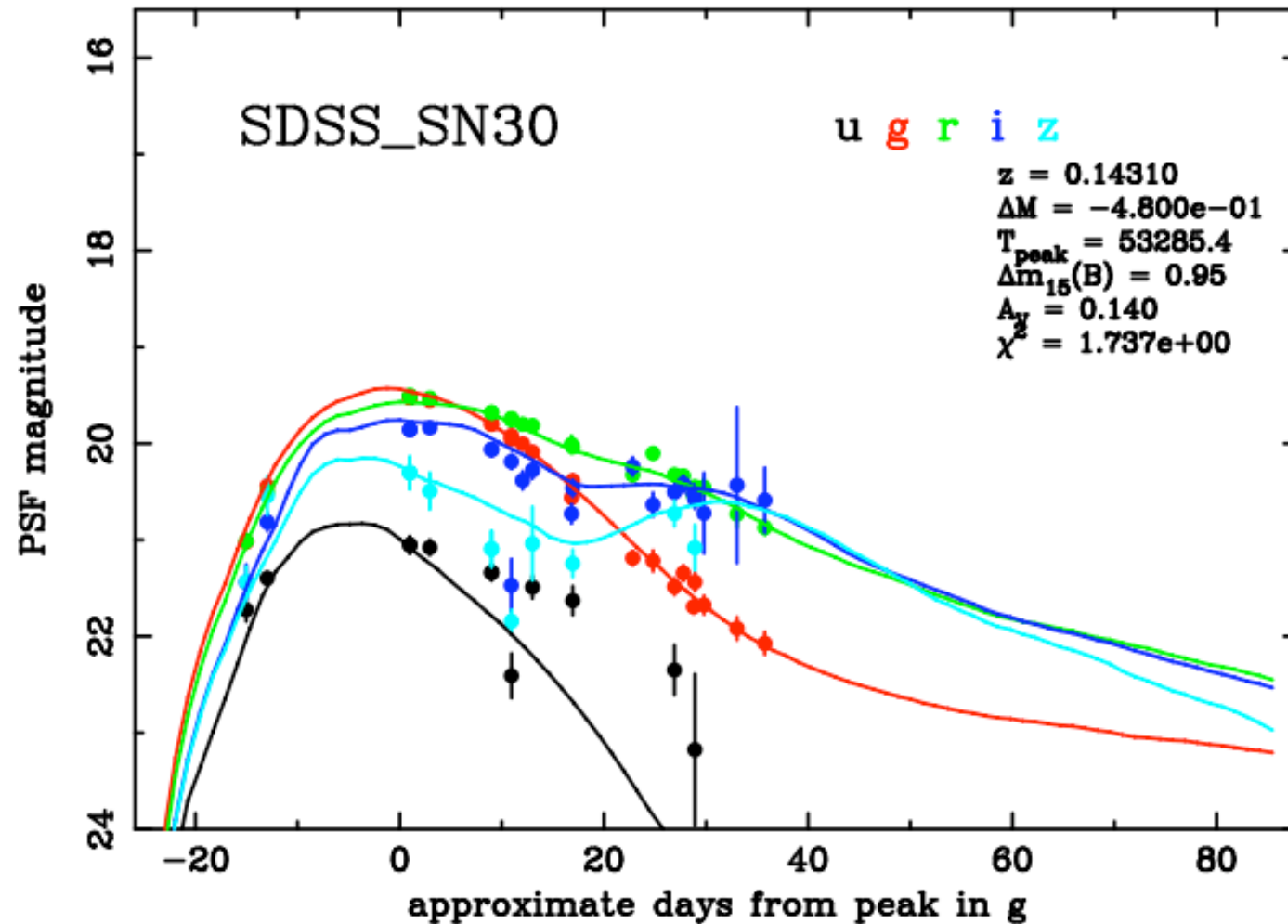


SN Ia $z=0.0513$
3 epochs of ARC 3.5m
spectroscopy

2004ie: Observed vs. Synthetic Light-curves (preliminary)

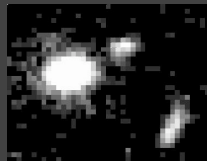


2004ia: Observed vs. Synthetic Light-curves (very preliminary)

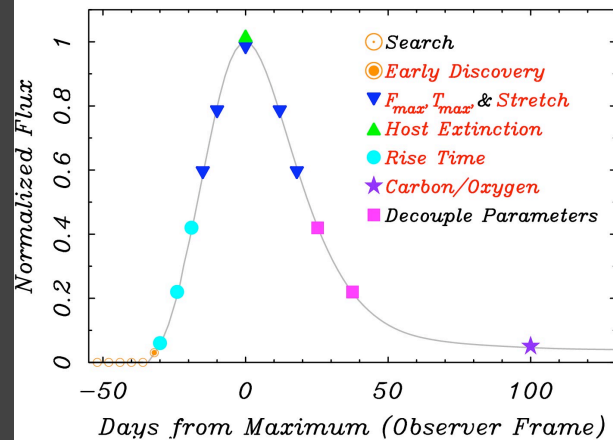


SN control of systematics

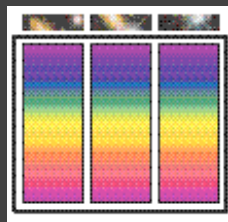
Images



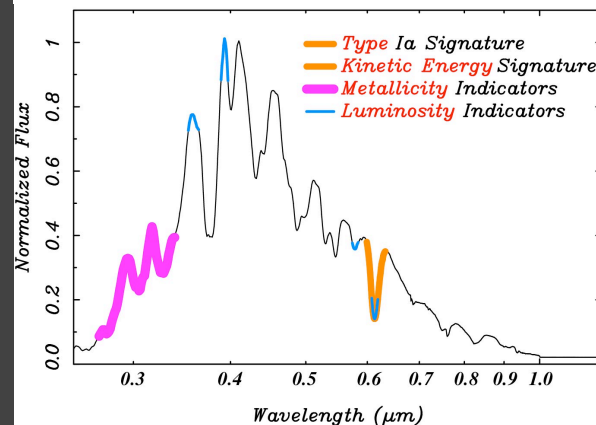
Lightcurve & Peak Brightness



Spectra



Redshift & SN Properties



Ω_M and Ω_Λ
Dark Energy Properties

data

analysis

physics